THE WEATHER AND CIRCULATION OF MARCH 1963

A Marked Reversal from February

JAMES F. ANDREWS

Extended Forecast Branch, U.S. Weather Bureau, Washington, D.C.

1. INTRODUCTION

March 1963 provided relief in the eastern half of the United States from one of the coldest winters ever observed [1]. In many areas the departure from normal of the average temperature was greater on the positive side by 10°–14° F. in March as compared to either the winter season (Dec.–Feb.) or to February. This was the warmest March since 1946 in most sections from the Northern Plains southeastward to the Tennessee Valley. By contrast, temperature anomalies in the Far Southwest and Great Basin were lower, relative to normal, in March as compared both to the winter season and to February. Largest changes from February, as much as 12° F., occurred in the Great Basin.

Record and near-record amounts of precipitation fell in the Ohio and Tennessee Valleys during March and resulted in considerable flooding. The longest flood of record at Cincinnati, Ohio, occurred when the Ohio River remained above flood stage for 22 consecutive days. Portions of the Southern Plains and lower Mississippi Valley continued to have a precipitation deficiency, and this March was one of the driest on record in some areas.

Mild temperatures in the Great Plains were also accompanied by unusually windy conditions. At Concordia, Kans., the average monthly wind speed was the highest ever observed in March since records began in 1885. These conditions resulted from a series of major storm systems moving across the Plains (section 5).

The abrupt transition from winter to spring in the East was associated with retrogression of the west coast ridge to the eastern Aleutians and its replacement by a deepening mean trough in March.

2. MONTHLY MEAN CIRCULATION

The average 700-mb. circulation for March 1963 (fig. 1) was characterized by meridional flow over the Pacific, and zonal flow across North America and the Atlantic. The westerlies generally were stronger than normal and displaced northward in the Western Hemisphere, a condition usually associated with mild weather in the United States.

A strong blocking ridge near 155° W. dominated the flow pattern over the Pacific. The positive height anomaly center associated with the ridge covered most of the Pacific and was the strongest anomaly of either sign in the Northern Hemisphere. This strong ridge was related to a slightly weaker than normal trough off the Asiatic coast and a deep trough west of the Hawaiian Islands (fig. 1). The main belt of westerlies was close to its normal position across the western Pacific, but displaced well north of normal in the area of the ridge (fig. 2).

A mean trough was the principal circulation feature along the west coast of North America. This trough was deeper than normal in the north and relatively weak in the south. The main belt of westerlies plunged southeastward from the eastern Pacific ridge and crossed Baja California, well south of normal (fig. 2). A weak ridge in the Pacific Northwest in conjunction with the lower portion of the coastal trough produced confluent flow from the Central Plains to the western Atlantic. Zonal flow across the United States was also evident at sea level, where pressures averaged above normal in the South and as much as 6 mb. below normal in the Northern Plains (see inset, Chart X of [2]). The deep mean Low centered north of Hudson Bay dominated the circulation over Canada where heights were almost entirely below normal. The jet axis associated with this Low accompanied above normal wind speeds along its path southeastward across Canada into the western Atlantic, where it merged with the jet axis from the southwestern United States (fig. 2).

Cyclonic flow associated with a deep trough and an extensive area of negative height anomaly dominated the circulation in the Atlantic (fig. 1). The Icelandic Low was near its usual position but was 15 mb. below normal. Frequent and rather slow-moving cyclones contributed to this deep center of action with the most intense system (minimum pressure 940 mb.) occurring on the 1st. This was one of the worst storms of the season in the North Atlantic as winds close to 100 kt. crested waves at 50 to 60 ft. At lower latitudes upper-level heights and sea level pressure were above normal. As a result of this strong south-north pressure gradient,

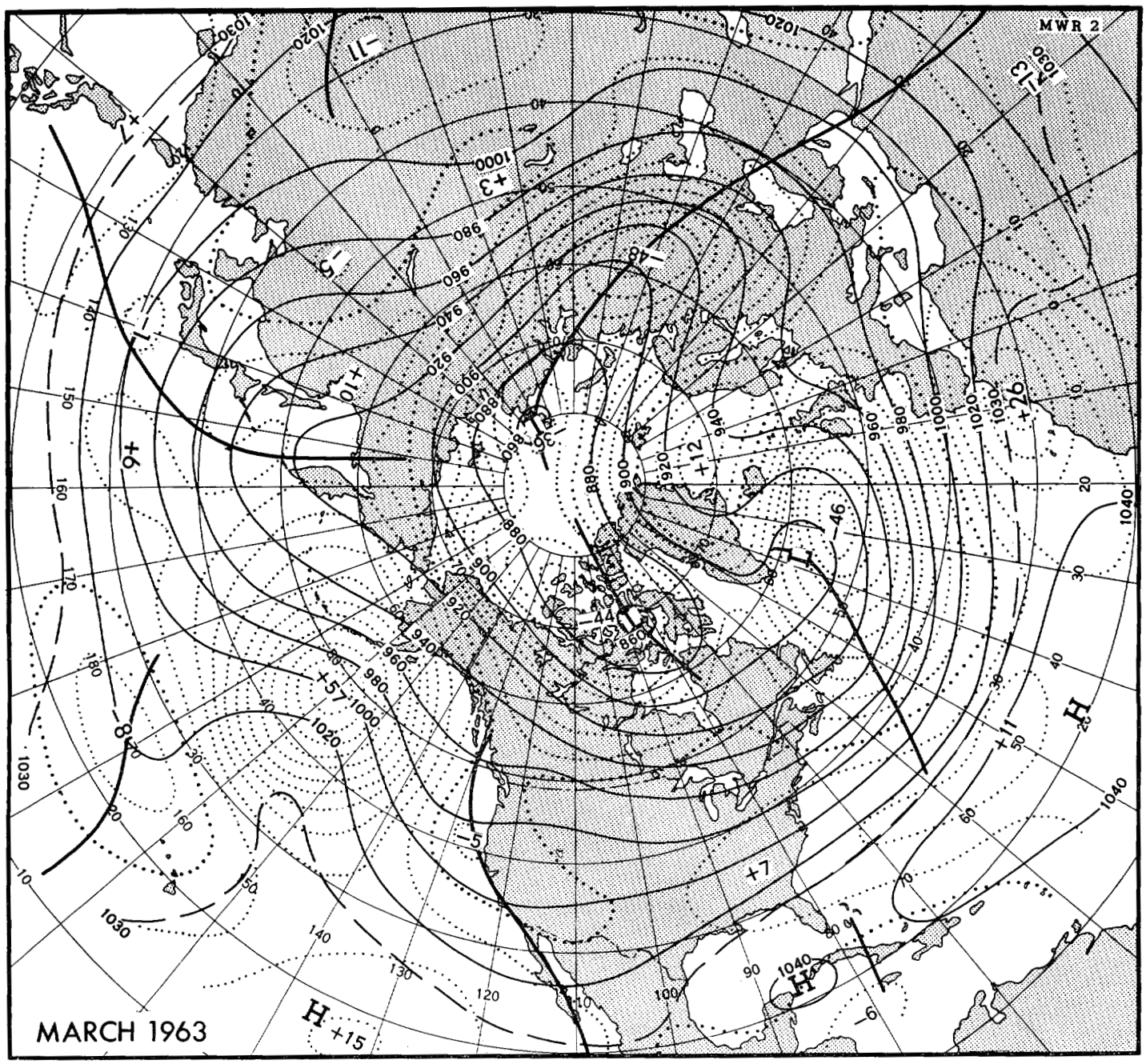

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for March 1963. Intense ridge in the eastern Pacific and zonal flow across North America and the Atlantic were features of the circulation.

the middle-latitude westerlies were 10 m.p.s. stronger than normal over the eastern Atlantic.

A characteristically maritime climate was re-established in Western Europe in March, thus replacing the severely cold continental regime of winter [1, 3]. Temperatures were generally close to their monthly normals as warmer Atlantic air dominated the area which was now under the influence of fast westerly flow from the Atlantic. Elsewhere in Europe, however, cold weather persisted as strong northerly flow between the ridge near Scandinavia and the deep full-latitude trough in Russia transported cold air southward. The coldest region, relative to normal, was northwestern Russia where Arkhangelsk reported an average temperature for March of 4.6° F., or 12.8° F. below normal. To the east the ridge observed over central Asia was rather weak considering the large-amplitude wave system in western Asia.

3. CIRCULATION EVOLUTION AND WEATHER TRENDS

The very persistent low zonal index circulation of December 1962 through February 1963 reverted abruptly

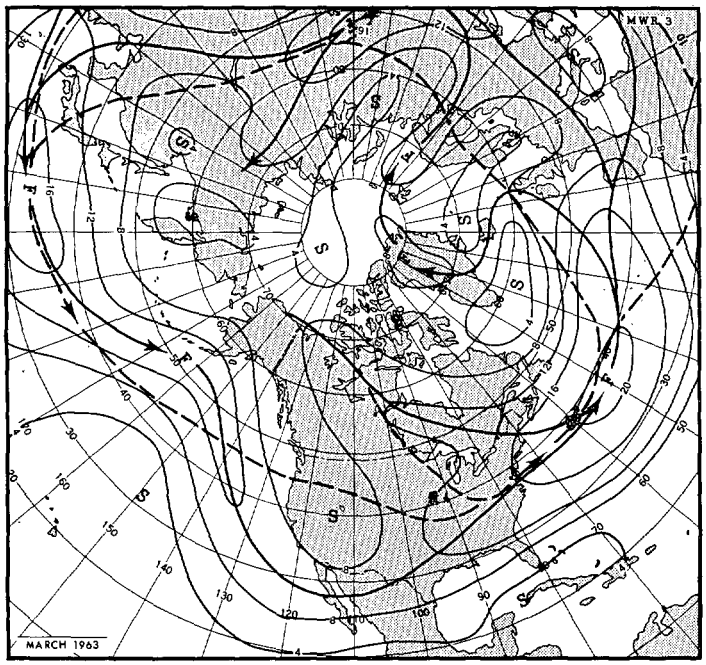

FIGURE 2.—Mean isotachs (in meters per second) at 700 mb. during March 1963. Solid arrows indicate the observed primary axis of maximum wind speed, dashed arrows the normal.

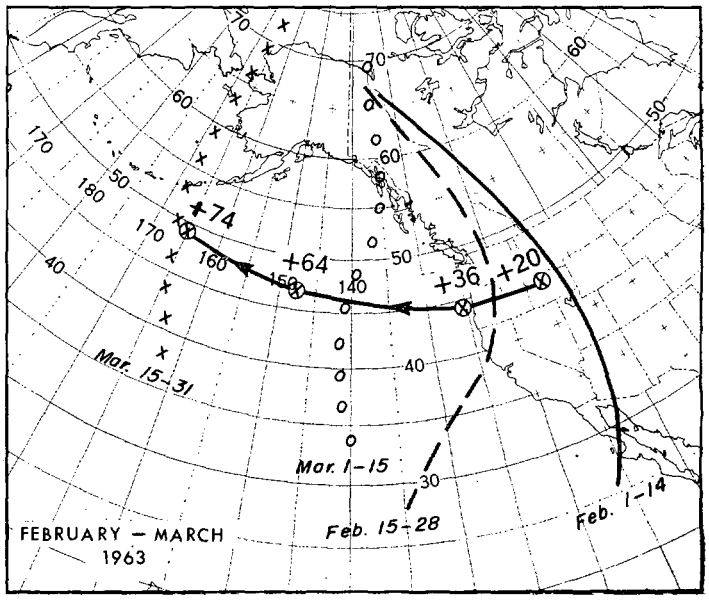

FIGURE 3.—Successive positions of western North America-eastern Pacific ridge from half-monthly mean charts during February and March 1963. Intensity of height anomaly (tens of feet) at each position is shown. Long-period retrogression and strengthening of this ridge led to a new circulation regime over North America and the Atlantic.

to a high index pattern during March. This circulation reversal was initiated primarily by retrogression and development of a new trough along the west coast of the United States. The trough development occurred in the manner described by Namias [4] and Winston [5] using 5-day mean charts, and will be described in section 5 on a week to week basis. This evolution was so slow, however, that it can also be traced on a series of 15-day mean charts.

Figure 3 shows the retrogression and intensification of the western North American ridge on a half-monthly mean basis during February and March. As the flow became more northerly east of the ridge, cold Arctic air was transported southward over the relatively warm waters of the Gulf of Alaska. Strong heating of the cold air and the addition of moisture led to large-scale convection and low-level horizontal convergence, thus creating the cyclonic vorticity which helped develop a mean trough along the west coast (fig. 1). The lower portion of the trough represented the southern part of the eastern North American trough which had retrograded and extended northward along the coast concurrent with the evolution described above. The Pacific Coast trough was, however, largely a new development since there was an increase in wave number from two to three in the area from the Pacific to the Atlantic (compare fig. 1 with fig. 1 in [1]). Also aiding in this trough formation was the increasing wavelength between the trough over eastern North America and the retrograding wave pattern in the Pacific.

Initiation of the Pacific Coast trough accompanied pronounced modification of the wave pattern downstream over North America and the Atlantic. In response to a shortened wavelength over North America and increased zonal flow, the east coast trough moved rapidly into the Atlantic where an intense Icelandic Low replaced the strong blocking pattern which had prevailed during the winter. At the same time a new mean ridge began to develop over the western United States.

The magnitude of this circulation reversal is seen in figure 4A which shows the change in 700-mb. height anomaly from February to March. Greatest change occurred in the Pacific where heights rose as much as 950 ft. as the deep Low in February was replaced by a strong ridge in March (fig. 1). Anomalous height changes over the United States and the temperature trend (relative to normal) between the two months (fig. 4B) were consistent. From the Plains States to the Atlantic Coast average temperatures became higher by three classes (from much below normal to above normal) at most stations where heights increased. In the West where heights decreased, a cooling trend of two to three classes occurred.

March was much wetter than February in a broad area from the Central Plains to the Middle Atlantic Coast (fig. 4C), largely as the result of a change to more southerly flow (fig. 4A). More northerly flow in the extreme Southeast produced a drying trend, with a similar trend also evident in the Southern Plains where the flow was still too westerly to result in much precipitation.

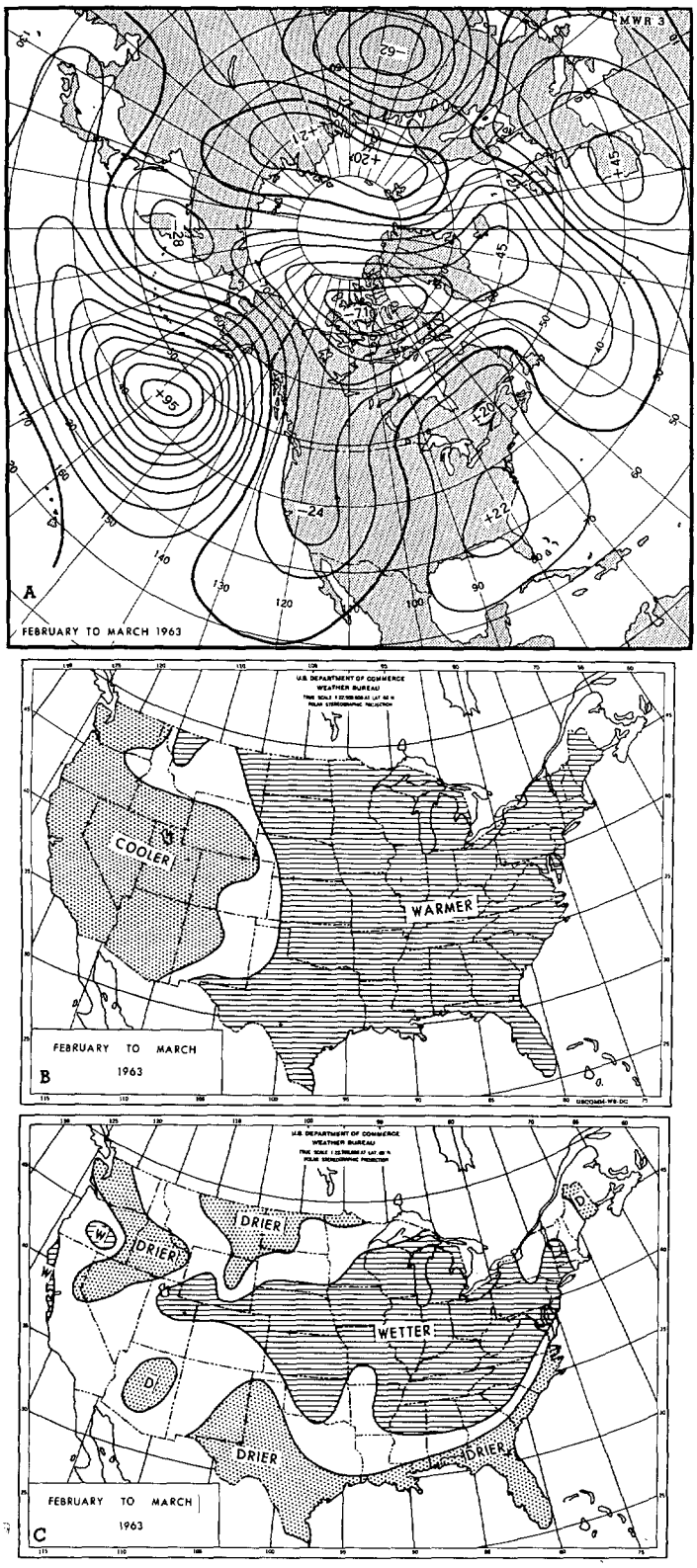

FIGURE 4.—Changes relative to normal from February to March 1963 of (A) 700-mb. height (tens of feet), (B) temperature, and (C) precipitation. Large height rises in the eastern Pacific were accompanied by a change to a warm wet weather regime in most of the eastern half of the Nation and a cooling trend in the West.

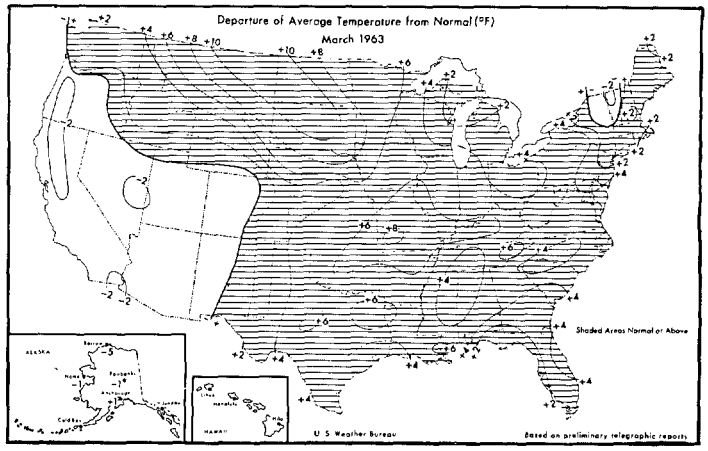

FIGURE 5.—Departure of average surface temperature (°F.) from normal for March 1963. (From [6].) Except for the Southwest and a small portion of the Northeast, unseasonably warm weather dominated the Nation.

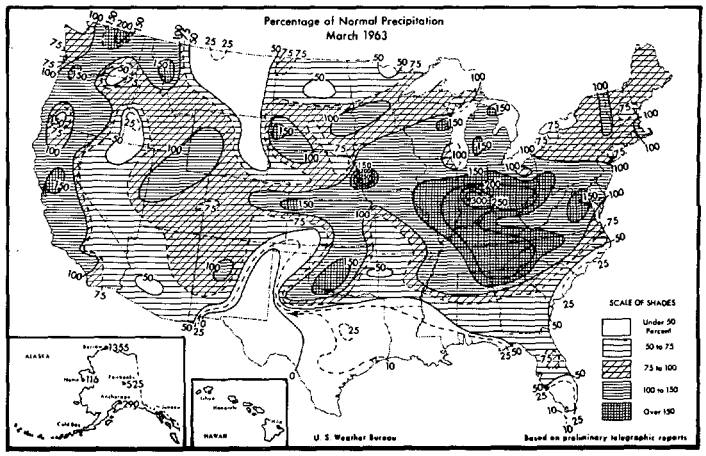

FIGURE 6.—Percentage of normal precipitation for March 1963. (From [6].) Monthly totals of 8 to 12 in. in the Ohio and Tennessee Valleys were more than twice normal.

4. UNITED STATES WEATHER ANOMALIES

Temperatures averaged higher than normal in nearly all but the southwestern quarter of the Nation (fig. 5). Greatest positive departures, more than 10° F., were observed in portions of the Northern Plains. These were related to stronger than normal westerly flow aloft and at the surface which produced considerable foehn warming.

Northerly flow into the trough along the west coast transported cool Pacific air masses into the Southwest where temperatures for the month averaged generally 1° to 2° F. below normal. These air masses were warmed considerably in passage over the Rocky Mountains so that mild Pacific air dominated the remainder of the Nation. A good correspondence existed during March between the average temperature departure from normal (fig. 5) and the anomaly pattern of mean 700-mb. height (fig. 1).

Precipitation in March (fig. 6) was unusually heavy in the Ohio and Tennessee Valleys. This was the wettest March of record at Parkersburg, W. Va., and Asheville, N.C., with near-record amounts in other areas. The combination of melting snow, rising temperatures, and heavy rains resulted in widespread flood conditions, particularly in the Ohio Basin. The area of above normal precipitation extended westward to the Central Plains (fig. 6) and was related to confluent flow at 700 mb. (fig. 1).

Also notable was the continued precipitation deficiency in the Southern Plains and lower Mississippi Valley where amounts were less than one-fourth of normal. Near record dryness prevailed in Texas and Louisiana in March; the first quarter of 1963 was the driest such period ever observed at Abilene and Dallas, Tex.

Precipitation amounts in the Pacific Coast States were generally near normal; much of this fell during the latter half of the month as the mean trough developed along the coast. The snowpack deficiency in the western mountains remained critical, but heavy snows near the end of the month eased the situation slightly. Snow depths, however, continued to be much below normal for this time of year, by as much as 40 to 60 in. at Stampede Pass, Wash.

Unusual weather in the Hawaiian Islands (fig. 1) was associated with the deep trough to the west. Most noteworthy was the frequent thunderstorm activity which accompanied several kona-type storms. Three times the normal amount of precipitation fell at Honolulu and, following the driest February of record at Lihue, March precipitation was well above normal. A temperature of 87° F. at this city was a March record.

5. WEEKLY EVOLUTION

WEEK ENDING MARCH 10

A large-amplitude wave pattern over North America early in the month consisted of a ridge in the eastern Pacific and a trough that extended from Hudson Bay into the Southern Plains (figs. 7A, B). Average temperatures were close to normal over much of the Nation (fig. 7C). Greatest departures were localized, with −12° F. at Denver, Colo., and Cheyenne, Wyo., and +12° F. at Havre, Mont. The temperature pattern, however, was a major change from a week earlier when the western half of the country had been warm and the eastern half much colder than normal.

Heavy precipitation fell from the Central Plains eastward, in association with the trough. Amounts of 4 in. or more fell locally in some areas, and the Ohio River reached flood level on the 6th. Nearly all of this precipitation accompanied passage of a major storm system from the Far Southwest, where it had developed the previous week, to the Midwest on the 4th and New England on the 6th (fig. 7B). Heavy snow fell from Colorado to New England with amounts averaging a foot or less. Earlier in the month (Mar. 1–2) a storm moving from the lower Mississippi Valley to New England had brought a heavy snowfall to much of the Northeast with rain to the south. A snowfall of nearly 9 in. at Boston, Mass., was the heaviest of the season.

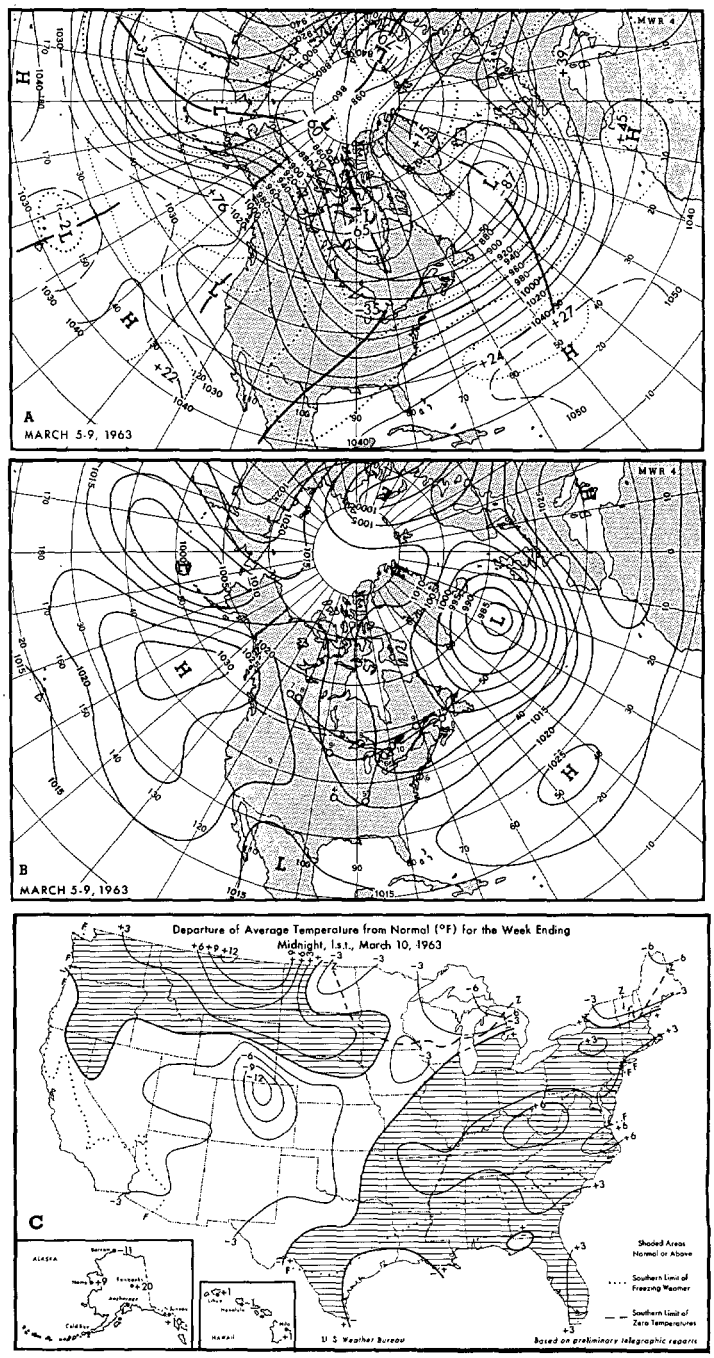

FIGURE 7.—(A) Five-day mean 700-mb. heights (solid) and departures from normal (dotted), both in tens of feet, and (B) five-day mean sea level isobars (in millibars) with tracks of principal cyclones in the United States, both for March 5–9, 1963. (C) Departure of average surface temperature from normal (° F.) for week ending March 10, 1963 (from [6]).

WEEK ENDING MARCH 17

Retrogression characterized the long-wave circulation during the second week. As the ridge in western North

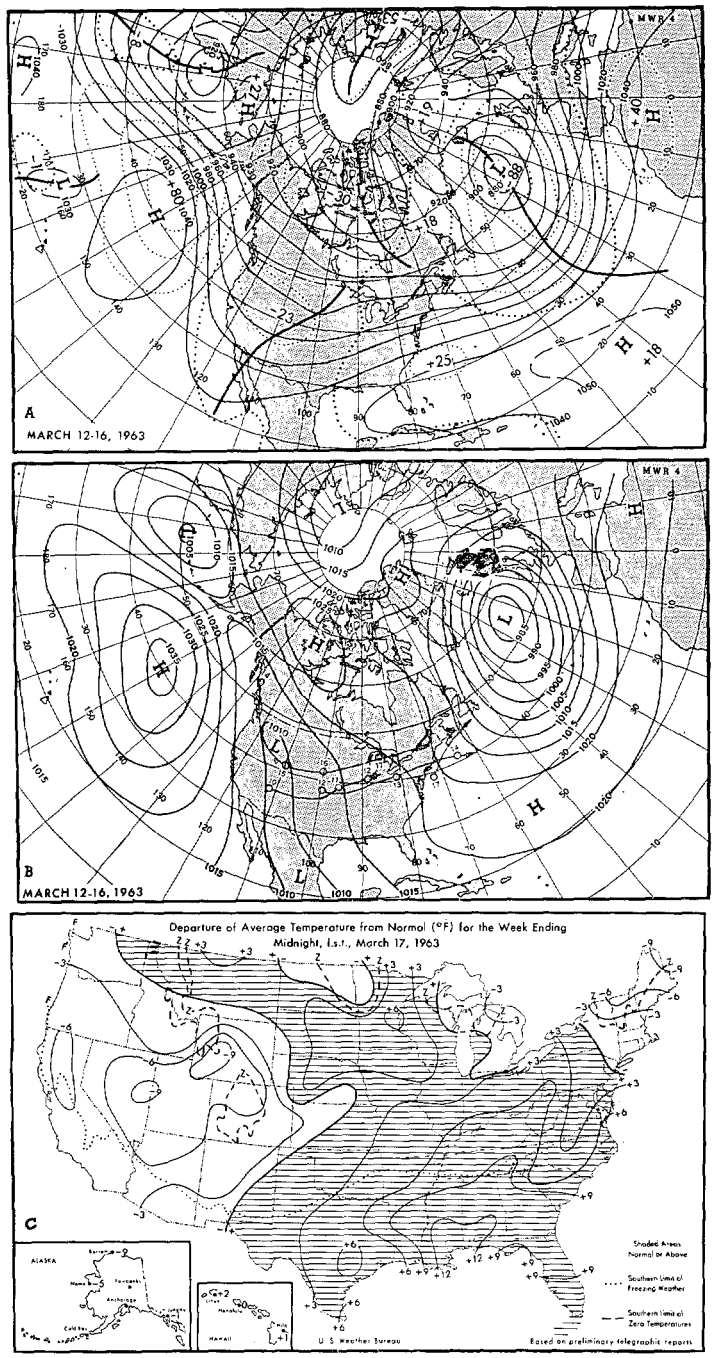

FIGURE 8.—(A) Five-day mean 700-mb. heights (solid) and departures from normal (dotted), both in tens of feet, and (B) five-day mean sea level isobars (in millibars) with tracks of principal cyclones in the United States, both for March 12–16, 1963. (C) Departure of average surface temperature from normal (° F.) for week ending March 17, 1963 (from [6]).

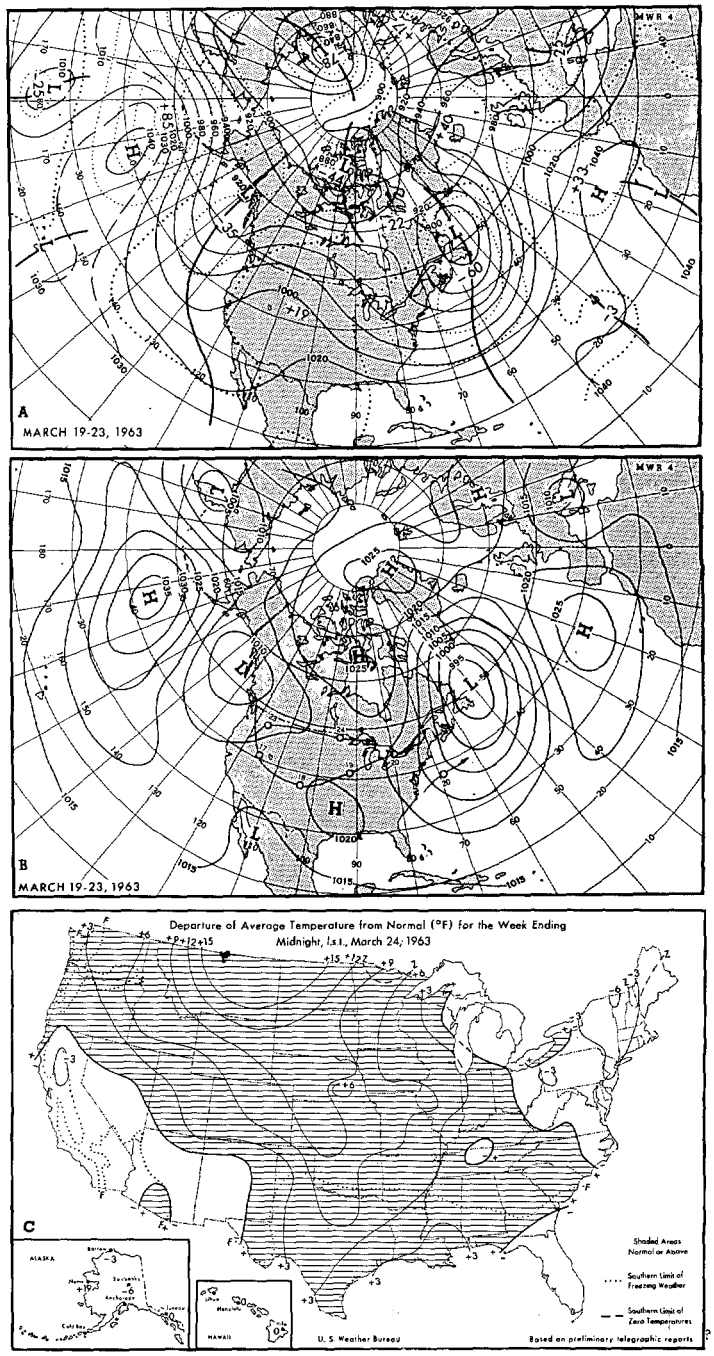

FIGURE 9.—(A) Five-day mean 700-mb. heights (solid) and departures from normal (botted), doht in tens of feet, and (B) five-day mean sea level isobbars (in milliars) with tracks of principal cyclones in the United States, both for March 19–23, 1963. (C) Departure of average surface temperature from normal (° F.) for week ending March 24, 1963 (from [6]).

America (fig. 7A) moved to the eastern Aleutians (fig. 8A), the flow over western North America became more cyclonic. This resulted from retrogression of the Mississippi Valley trough (fig. 7A) and an incipient trough along the Canadian coast (fig. 8A). At the same time the flat ridge formerly over the western Atlantic strengthened as it moved to the Atlantic coast. The retrogressive nature of the wave pattern at this time is also indicated by the westward displacement of the centers of height anomaly.

These circulation changes were accompanied by a temperature pattern of mostly lower than normal in the

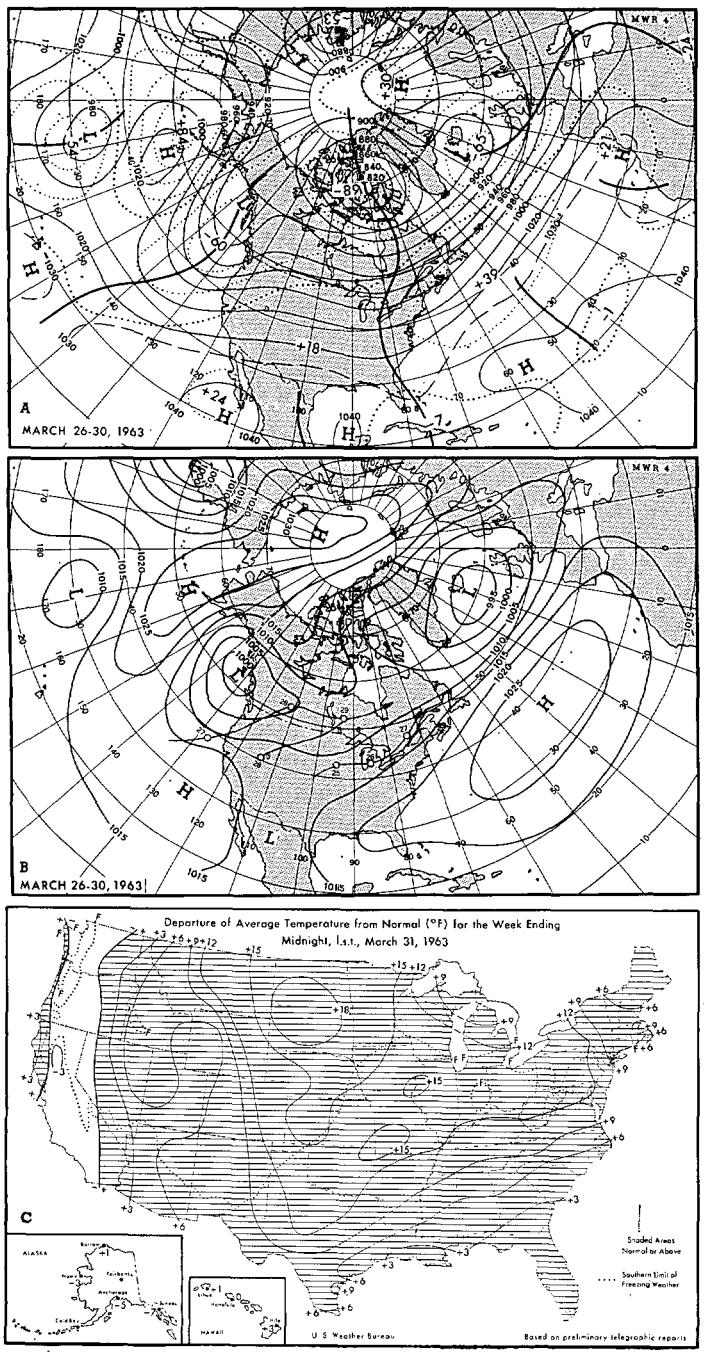

FIGURE 10.—(A) Five-day mean 700-mb. heights (solid) and departures from normal (dotted), both in tens of feet, and (B) five-day mean sea level isobars (in millibars) with tracks of principal cyclones in the United States, both for March 26–30, 1963. (C) Departures of average surface temperature from normal (° F.) for week ending March 31, 1963 (from [6]).

West and higher than normal from the Great Plains eastward (fig. 8C). Southerly flow aloft (fig. 8A) and at sea level (fig. 8B) effected a warming trend in the latter area with greatest departures in the Southeast. A temperature of 91° F. at Baton Rouge, La., on the 17th tied their record high temperature for any March. New England, under the influence of northerly flow, continued to have subnormal temperatures. Daily minimum temperature records were established at Burlington, Vt., on the 15th and 16th, with −9° F. on the 16th the lowest recorded so late in the season.

Much of the eastern half of the country continued to receive heavy precipitation with heaviest amounts again concentrated in the Ohio and Tennessee Valleys and the central and southern Appalachians. Critical flooding developed in West Virginia, Virginia, and Kentucky, while the Ohio River remained well over flood level in the middle and lower reaches. Near to above normal amounts of precipitation fell throughout much of the Far West and the northern and central Great Plains. This was associated with a series of storm systems which developed in the Far West and moved eastward to New England (fig. 8B). The most intense storm moved in from the Pacific on the 14th. Its passage eastward was accompanied by a variety of weather conditions typical of March. There was blowing dust over the southwestern States, blizzard conditions in the Northern Plains, and severe local storms from Iowa and Missouri eastward. An 8-in. snowfall at Salt Lake City, Utah, was followed on the 16th by a temperature of 10° F., the lowest ever recorded there so late in the season. Winds gusted to more than 60 m.p.h. in some areas of the Rocky Mountain States and northern and central Great Plains.

WEEK ENDING MARCH 24

The long-wave pattern continued to retrograde during the third week, and it also amplified. A deep trough became established in the eastern Pacific with mean Low in the eastern Gulf of Alaska (figs. 9A, B). The trough which had occupied the West previously was now replaced by a ridge and area of positive height anomaly. Large changes also were observed in the Atlantic where the intense mean Low was displaced 25° of longitude to the west.

A corresponding retrogression was also evident in the temperature anomaly pattern in the United States (figs. 8C, 9C). The West warmed considerably, with temperature anomaly changes from the previous week of +10° to +15° F. in upper portions of the Great Plains and Rockies. Greatest departures, as much as +16° F., were observed in the Northern Plains where fast westerly flow resulted in foehn warming. Northerly flow from the Mississippi Valley eastward lowered temperatures in this region with the greatest cooling in the Southeast.

There was less storminess during the period with most of the Nation experiencing the passage of only one major Low (fig. 9B). This system moved eastward from the Great Basin on the 17th, spreading moderate to heavy precipitation from the Central Plains over the Ohio Valley and much of the Appalachians. Totals for the week in the latter areas, however, were much less than during the previous two weeks. A rare situation developed on the Ohio River when, due to progressive con-

tributions of previous rainfall and runoff, the middle and lower portions of the river crested at the same time as much of the upper river.

WEEK ENDING MARCH 31

The "omega" blocking pattern which appeared in the Pacific in the previous week strengthened during the last week as the eastern Pacific trough deepened and continued to retrograde in the south (figs. 9A, 10A). Strong southwesterly flow ahead of this trough, in combination with an intense upper Low in northeastern Canada, produced fast westerly flow across North America and the Atlantic at 700 mb. and at sea level (fig. 10B). This accompanied rapid eastward motion of the western Atlantic trough and the development southward of a full-latitude trough over eastern North America, but the United States portion of this trough was much weaker than normal.

Except for slightly below normal temperature averages in much of the west coast region, the Nation was unseasonably warm during the last week (fig. 10C). Departures of $+10°$ to $+15°$ F. were common from the Continental Divide to the Middle Atlantic Coast and numerous daily maximum temperature records were established at many stations near the end of the week.

The deep trough in the eastern Pacific brought heavy precipitation to the West Coast States with amounts up to 5 in. along the coast and at the higher elevations. An intense storm moving in from the Pacific on the 27th (fig. 10B) was accompanied by gale force winds in the Northwest. Winds gusted to 75 m.p.h. at Eugene, Oreg., and 66 m.p.h. at Sheridan, Wyo., the highest wind speed observed at that station in any March. The Ohio River, above flood stage since March 6, was finally contained within its banks on the 27th.

REFERENCES

1. R. A. Green, "The Weather and Circulation of February 1963—A Warm Month in the West and Continued Cold in the East," *Monthly Weather Review*, vol. 91, No. 5, May 1963, pp. 264–270.
2. U.S. Weather Bureau, *Climatological Data, National Summary*, vol. 14, No. 3, March 1963, Chart X.
3. J. F. O'Connor, "The Weather and Circulation of January 1963—One of the Most Severe Months on Record in the United States and Europe," *Monthly Weather Review*, vol. 91, No. 4, Apr. 1963, pp. 209–217.
4. J. Namias, *Extended Forecasting by Mean Circulation Methods*, U.S. Weather Bureau, 1947, (pp. 30–34).
5. J. S. Winston, "Physical Aspects of Rapid Cyclogenesis in the Gulf of Alaska," *Tellus*, vol. 7, No. 4, Nov. 1955, pp. 481–500.
6. U.S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. L, Nos. 10–14, Mar 11, 18, 25, and Apr. 1, 8, 1963.

CORRECTION

The pagination for the May issue is incorrect. Each page number should be increased by 44. The ANNUAL INDEX in the December issue will use the corrected page numbers shown in the corrected table of contents below.